STRUCTURAL EARTH WALL
June 3, 1996

General Requirements

1.01 Description

A. This work consists of constructing the preapproved structural earth walls in accordance with the Plans, the Standard Specifications and these Special Provisions, and in conformity with the lines, grades, design and dimensions shown in the Plans or as established by the Engineer.

B. The structural earth walls shall be constructed of only one of the following three wall types; either Reinforced Earth, Retained Earth, or Reinforced Soil.

1. Reinforced Earth is a registered trade mark of the Reinforced Earth Company.

2. Retained Earth is a registered trademark of the VSL Corporation.

3. Reinforced Soil is a registered trademark of Hilfiker Retaining Walls.

1.02 Quality Assurance

A. The completed wall shall meet the following tolerances:

1. Vertical tolerances and horizontal tolerances shall not exceed 20 millimeters when measured along a 3 meter straight edge.

2. The overall vertical tolerances of the wall shall not exceed 12 millimeters per 3 meters of wall height.

3. The maximum allowable offset in any panel joint shall be 20 millimeters.

B. The structural earth wall manufacturer shall provide a qualified and experienced representative at the job site, at the start of wall construction and as needed, to resolve wall construction problems as directed by the Engineer. Recommendations made by the representative and approved by the Engineer shall be followed by the Contractor.

1.03 Submittals

A. The Contractor, or the supplier as the Contractor's agent, shall furnish to the Engineer a Certificate of Compliance certifying that the structural earth wall materials comply with the applicable sections of these Specifications.

B. A copy of all test results performed by the Contractor or the Contractor's supplier which are necessary to assure compliance with the specifications shall also be furnished to the Engineer.

C. Before fabrication, the Contractor shall submit a field construction manual for the structural earth walls, prepared by the wall manufacturer, to the Engineer for approval in accordance with Section 6-01.9. This manual shall provide step-by-step directions for construction of the wall system.

D. Design Calculations and Shop Drawings

The Contractor, or the supplier as the Contractor's agent shall submit detailed design calculations and shop drawings to the Engineer for approval in accordance with Section 6-01.9 and this Special Provision. The Contractor shall not begin wall construction (including concrete facing panel fabrication) without the Engineer's written approval of the design calculations and shop plans.

The submittal shall include detailed design calculations and all details, dimensions, quantities, and cross-sections necessary to construct the wall. The calculations shall include a detailed explanation of any symbols and computer programs used in the design of the walls. All computer output submitted shall be accompanied by supporting hand calculations detailing the calculation process.

The design calculations shall be based on the current AASHTO Standard Specifications for Highway Bridges including current interims, and also based on the following:

a. The factor of safety for overturning and sliding are 2.0 and 1.5 respectively for AASHTO Load Group I, and 1.5 and 1.1 respectively for AASHTO Load Group VII.
b. The slope of the backfill shown in the Plans.

c. If the wall is adjacent to a highway, a 600 millimeter surcharge shall be used in the design.

d. If the Plans detail a traffic barrier on top of the wall, the barrier and wall shall be capable of resisting a 44.5 kilonewton horizontal load applied at the top of the barrier.

e. The following design parameters shall be used:

Soil Properites	**Wall Backfill**	**Retained Soil**	**Foundation Soil**
Unit Weight (kNm3)	***$$1$$***	***$$2$$***	***$$3$$***
Friction Angle (deg)	***$$4$$***	***$$5$$***	***$$6$$***
Cohesion (P)	***$$7$$***	***$$8$$***	***$$9$$***

	AASHTO Load Group 1	AASHTO Load Group VII
Allowable Bearing Capacity (kP)	***$$10$$***	***$$11$$***
Acceleration Coefficient (g)	N/A	***$$12$$***

A minimum of six sets of shop plans shall be fully detailed and submitted on 610 by 915 millimeter or 558 by 864 millimeter sheets and shall include, but not be limited to, the following items:

a. A plan and elevation sheet or sheets for each wall, containing the following:

1. An elevation view of the wall which shall indicate the elevation at the top of the wall, at all horizontal and vertical break points and at least every 15 meters along the wall; elevations at the top of leveling pads and foundations, the distance along the face of the wall to all steps in the foundations and leveling pads; the designation as to the type of panel or module; the length, size, and number of mesh or strips and the distance along the face of the wall to where changes in length of the mesh or strips occur; and the location of the original and final ground line.

2. A plan view of the wall which shall indicate the offset from the construction centerline to the face of the wall at all changes in horizontal alignment; the limit of the widest module, mesh, or strip, and the centerline of any drainage structure or drainage pipe which is behind or passes under or through the wall.

3. Any general notes required for design and construction of the wall.

4. All horizontal and vertical curve data affecting wall construction.

5. A listing of the summary of quantities provided on the elevation sheet of each wall for all items including incidental items.

6. Cross-section showing limits of construction. In fill sections, the cross-section shall show the limits and extent of select granular backfill material placed above original ground.

7. Limits and extent of reinforced soil volume.

b. All details including reinforcing bar bending details. Bar bending details shall be in accordance with Section 9-07.1.

c. All details for foundations and leveling pads, including details for steps in the foundations or leveling pads, as well as allowable and actual maximum bearing pressures.

d. All modules and facing elements shall be detailed. The details shall show all dimensions necessary to construct the element, all reinforcing steel in the element, and the location of reinforcement element attachment devices embedded in the facing.

e. All details for construction of the wall around drainage facilities, overhead sign footings, and abutment piles shall be clearly shown.

f. All details for connections to traffic barriers, coping, parapets, noise walls, and attached lighting shall be shown.

g. All details for the traffic barrier attached to the top of the wall (if shown in the Plans).

h. The plans shall be prepared and signed by a professional engineer, licensed in the State of Washington.

Materials

2.01 General

A. The Contractor shall make arrangements to purchase the concrete facing panels, reinforcing strips or reinforcing mesh, attachment devices, joint filler, and all necessary incidentals from one of the following three sources:

1. The Reinforced Earth Company
   6 Morgan Suite 100
   Irvine, CA 92718
   (714) 587-3060

2. VSL Corporation
   1077 Dell Avenue
   Campbell, CA 95008
   (408) 866-5000

3. Hilfiker Retaining Walls
   P.O. box 2012
   Eureka, CA 95501-2012
   (707) 443-5093
   FAX (707) 443-2891

2.02 Concrete Facing Panels

A. Materials

1. All materials shall meet the requirements of Division 9. Fly ash (optional) shall meet the requirements of Section 9-23.9.

B. Design Requirements

1. The Contractor shall design the concrete mix in accordance with concrete Class 28 and the requirements for Section 6-02.3(2)A except as modified by this Special Provision.

C. Testing and Inspection

1. Acceptability of the panels will be determined on the basis of compressive strength tests and visual inspection.

2. The panels shall be considered acceptable regardless of curing age when compressive test results indicate that the compressive strength conforms to the 28-day requirements and when the visual inspection is satisfactorily completed.

3. Testing and inspection of precast concrete panels shall conform to Section 6-02.3(28).

D. Casting

1. Tie attachment devices shall be set in place to the dimensions and tolerances shown in the Plans prior to casting.

E. Curing

1. The panels shall be cured for a sufficient length of time so that the concrete will develop the specified compressive strength.

F. Removal of Forms

1. The forms shall remain in place until the concrete has reached a minimum compressive strength of 14 MPa in accordance with Section 6-02.3(28)D.

G. Finish

1. The concrete surface for the front face shall have the finish shown in the Plans and an unformed finish for the rear face.

2. The rear face of the panel shall be roughly screeded to eliminate open pockets of aggregate and surface distortions in excess of 6 millimeters.

H. Tolerances

1. All panels shall be manufactured within the following tolerances:

a. All dimensions $\pm$ 5 millimeters.

b. Squareness, as determined by the difference between the two diagonals, shall not exceed 12 millimeters.

c. Surface defects on smooth formed surfaces measured on a length of 1.5 meters shall not exceed 3 millimeters. Surface defects on textured-finished surfaces measured on a length of 1.5 meters shall not exceed 8 millimeters.

I. Marking

1. The date of manufacture, production lot number, and the piece-mark, shall be clearly marked on the rear face of each panel.

J. Handling, Storage, and Shipping

1. All panels shall be handled, stored, and shipped in such a manner as to eliminate the danger of chipping, cracks, fractures, and excessive bending stresses.

2. Panels in storage shall be supported on firm blocking located immediately adjacent to tie strips to avoid bending the tie strips.

2.03 Reinforcing Strips

A. Reinforcing strips shall be shop fabricated from hot rolled steel conform to the requirements of AASHTO M 223 Grade 65 or approved equal.

B. Reinforcing strips shall be hot-dip galvanized in accordance with AASHTO M 111. Damage to galvanizing shall be repaired with Formula A-9-73 Galvanizing Repair Paint in accordance with Section 9-08.2.

2.04 Reinforcing Mesh

A. The reinforcing mesh shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of AASHTO M 32 and shall be welded into finished mesh fabric in accordance with AASHTO M 55.

B. Reinforcing mesh shall be hot-dip galvanized in accordance with M 111. Damage to the galvanizing shall be repaired with Formula A-9-73 Galvanizing Repair Paint in accordance with Section 9-08.2.

2.05 Tie Strips

A. Tie strips shall be shop fabricated from hot rolled steel conforming to the requirements of ASTM A570 Grade 50 or approved equal.

B. Tie strips shall be hot-dip galvanized in accordance with AASHTO M 111. Damage to the galvanizing shall be repaired with Formula A-9-73 Galvanizing Repair Paint in accordance with Section 9-08.2.

2.06 Fasteners - Reinforced Earth Wall

A. The 12 millimeter diameter bolts and nuts shall be high strength hexagonal cap screws, conforming to AASHTO M 164, galvanized per AASHTO M 232.

2.07 Fasteners - Retained Earth Wall

A. The 9.525 millimeter diameter or 7.010 millimeter diameter embed loop shall be fabricated of steel wire conforming to AASHTO M 32 and shall be galvanized in accordance with AASHTO M 111.

B. The 12.70 millimeter diameter or 7.010 millimeter diameter connector bar shall be fabricated of steel wire ductile iron conforming to AASHTO M 32 and galvanized in accordance with AASHTO M 111.

2.08 Joint Materials - Reinforced Earth Wall

A. Rubber bearing pads shall be a type and grade as recommended by the Reinforced Earth Company.

B. Vertical joint filler between panels, when specified in the plans, shall be flexible open cell polyether foam strips, Grade UU-34, 50 millimeters by 50 millimeters as recommended by the Reinforced Earth Company.

C. Filter fabric joint cover for both horizontal and vertical joints, when specified in the plans, shall be a pervious woven polypropylene filter fabric as recommended by the Reinforced Earth Company. Adhesive used to attach the fabric material to the rear of the panel shall be as recommended by the Reinforced Earth Company.

2.09 Joint Materials - Retained Earth Wall

A. The material to be attached to the rear side of the facing panel covering the inclined and horizontal joints between panels shall be monofilament filter fabric as recommended by the VSL Corporation. Adhesive used to attach the fabric to the panel shall be as recommended by the VSL Corporation.

2.10 Concrete Leveling Pad

A. Concrete for the leveling pad shall be Class 20 concrete conforming to Section 6-02.

2.11 Backfill Material

A. All backfill material used in the structural earth compaction zone shall be free draining, free from organic or otherwise deleterious material and shall conform to the specifications for gravel borrow as specified in Section 9-03.14(1).

B. The material shall be substantially free of shale or other soft, poor durability particles. The material shall have magnesium sulfate soundness loss of less than 30 percent after four cycles. The Contractor shall provide the Engineer with test results from an independent laboratory for the magnesium sulfate soundness loss test. The test shall be conducted in accordance with ASTM C 88.

C. The material shall meet the following corrosive requirements:

Resistivity - greater than 3000 ohm-cm.
PH - 5 to 10
Chlorides - less than 200 mg/kg
Sulfates - less than 1000 mg/kg
Sulphides - less than 300 mg/kg

Construction Requirements

3.01 Wall Excavation

A. Excavation shall be in accordance with the requirements of Section 2-09 and in conformity to the limits and construction stages shown in the plans.

3.02 Foundation Preparation

A. The foundation for the structure shall be graded level for a width equal to or exceeding the length of reinforcing as shown in the approved shop drawings.

B. Prior to wall construction, the foundation, if not in rock, shall be compacted as directed by the Engineer.

C. Any foundation soils found to be unsuitable shall be removed and replaced as provided for under Section 2-09.3(1)C.

D. At each panel foundation level, an unreinforced concrete leveling pad shall be provided as shown in the plans. The leveling pad shall be cured a minimum of 12 hours before placement of wall panels.

3.03 Concrete Facing Panels

A. Construction Requirements

1. Concrete shall meet the following requirements:

a. Have a minimum 28 day compressive strength of 28 MPa.

b. Contain a water-reducing admixture meeting AASHTO M 194 Type A, D, F, or G.

c. Be air-entrained, 6 percent ± 1 1/2 percent.

d. Have a maximum slump of 200 millimeters, 300 millimeters if a Type F or G water reducer is used.

3.04 Wall Erection

A. The panels shall be placed vertically. For erection, panels are handled by means of a lifting device set into the upper edge of the panels.

B. Panels shall be placed in successive horizontal lifts in the sequence shown in the plans as backfill placement proceeds.

C. External bracing is required for the initial lift.

D. As backfill material is placed behind the panels, the panels shall be maintained in vertical position by means of temporary wooden wedges placed in the joint at the junction of the two adjacent panels on the external side of the wall.

E. Reinforcing shall be placed normal to the face of the wall, unless otherwise shown in the Plans or directed by the Engineer. Prior to placement of the reinforcing, backfill shall be compacted.

3.05 Backfill Placement

A. Backfill placement shall closely follow erection of each course of panels. Backfill shall be placed in such a manner as to avoid any damage or disturbance to the wall materials or misalignment of the panels.

B. Any wall materials which become damaged or disturbed during backfill placement shall be either removed and replaced at the Contractor's expense or repaired and corrected as directed by the Engineer.

C. Any misalignment or distortion of the panels due to placement of backfill outside the limits of this specification shall be corrected as directed by the Engineer.

D. The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer of material:

1. The moisture content of all backfill material shall meet the requirements of Section 2-03.3(14)C, Method C.

2. Backfill material with a placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniformly acceptable throughout the entire lift.

3. The Optimum Moisture Content shall be determined in accordance with Section 2-03.3(14)D.

E. Backfill shall be compacted to 95 percent of the maximum density as specified under Compacting Earth Embankments, Method C, in Section 2-03.3(14)C, except as modified herein:

1. The maximum lift thickness after compaction shall not exceed 250 millimeters.

2. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density.

3. Compaction within 1 meter of the back of the wall facing panels shall be achieved using either a backfill rammer tamper or a vibratory plate compactor. No soil density tests shall be taken within this area.

F. At the end of each day's operation, the Contractor shall shape the last level of backfill to permit runoff of rainwater away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

Measurement

4.01 Structural Earth Wall

A. The structural earth walls will be measured by the square meter of completed wall in place. The vertical limits for measurement are from the foundation to the top of wall as shown in the Plans. The horizontal limits for measurement are from the end of wall to the end of wall.

B. The backfill material will be measured by the cubic meter in place determined by the limits shown in the Plans.

C. Excavation will be measured by the cubic meter to the limits shown in the Plans.

Payment

5.01 Structural Earth Wall

A. The unit contract price per square meter for "Structural Earth Wall" shall be full pay for performing the wall construction work, including the leveling pad, as specified.

B. The unit contract price per cubic meter for "Backfill for Structural Earth Wall Incl. Haul" shall be full pay for furnishing, processing, hauling, placing, and compacting the backfill material.

C. All costs in connection with excavation will be paid by the cubic meter as "Structure Excavation Class B Incl. Haul" in accordance with Section 2-09.5.